REMARKS

In the last Office Action, claims 1-4 were rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No. 6,274,290 to Veneklasen et al. ("Veneklasen"). The Examiner stated that Veneklasen discloses the setting of pixel size according to beam diameter, which is essentially the same as breaking up a pattern into plural microscopic portions that are equal in size to the beam width. The Examiner further stated that the beam is held in a steady state during exposure so that the dose amounts will be equal for all portions, depending upon the scan rate.

By the present response, the specification has been suitably revised in editorial respects to correct informalities and improve the wording. Claims 1-6 have been canceled without prejudice or admission and replaced by new claims 7-26, which include revised versions of the original claims rewritten in formal respects to improve the wording and to more particularly point out and distinctly claim the novel subject matter of the present invention. The newly added claims further include independent claims of varying scope to provide a more comprehensive scope of coverage.

Applicants respectfully submit that claims 7-26 patentably distinguish over the prior art of record.

The present invention relates to an improved charged particle beam processing method which overcomes various problems associated with prior art techniques.

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As pointed out at pages 1-5 of the specification, a focused ion beam does not have a square characteristic and instead has a normal distribution. Thus, when a spot on a sample is irradiated by the focused ion beam during deposition or etching, for example, the amount of etching or deposition performed at the irradiated portion of the sample also has a normal distribution. Since the energy at the center of the beam is greater than at the peripheral edges, a higher degree of processing is performed at the center of the beam than at the peripheral edges. The effects of this processing irregularity are greater in smaller patterns than in large patterns. For example, as illustrated by Figs. 2A and 2B of the application drawings, a small pattern "a" has a highly irregular deposition distribution whereas a large pattern "b" has a relatively even distribution pattern. As can be seen by the cross-sectional diagrams of Fig. 2, these processing irregularities are greater at the boundaries of processed patterns than at central portions of the patterns. This is because centrally-located regions of a pattern are exposed to the particle beam for a greater period of time than boundary portions of the pattern.

The present invention overcomes the foregoing problem by providing an improved charged particle beam processing method in which uniform processing is achieved so

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that the same amount of irradiation is applied to central portions of a pattern as to the boundary portions of the pattern.

For example, uniform processing can be achieved in accordance with the present invention by slower scanning of the charged particle beam at boundary portions of a processed pattern as compared to central portions.

More specifically, in accordance with one novel aspect of the present invention recited by newly added independent claim 7, a charged particle beam processing method comprises the steps of dividing a pattern to be processed by a charged particle beam into a plurality of microscopic regions each having a size slightly smaller than a diameter of the charged particle beam, scanning the charged particle beam across the pattern, and varying a frequency of the scanning so that each of the respective microscopic regions has an equal dose of irradiation applied thereto by the charged particle beam.

By varying the frequency of the scanning to increase the amount of scanning of microscopic regions at boundary portions of the pattern relative to that of microscopic regions at interior portions of the pattern, the non-uniformity associated with prior art techniques is avoided.

In accordance with another aspect of the invention recited by newly added independent claim 12, irradiation

amount distribution information is obtained for each of the microscopic regions necessary to obtain the same irradiation amount for each of the microscopic regions, and scanning of the charged particle beam across the pattern is performed based on the irradiation amount distribution information.

For instance, the irradiation amount distribution information may be determined for respective microscopic regions based upon their relative location in the pattern, such that microscopic regions at boundary portions of the pattern are scanned more slowly than those at interior portions of the pattern. The irradiation amount for each respective microscopic region may be determined based upon a number of directly adjacent microscopic regions thereto, so that microscopic regions with a smaller number of directly adjacent regions (such as those at boundary portions of the pattern) may be scanned more frequently than those which have a larger number of directly adjacent microscopic regions (such as those within the pattern) so that an equal dosage of irradiation is applied to each microscopic region.

In accordance with yet another aspect of the invention recited by independent claim 22, the dosage of irradiation is maintained constant by storing irradiation amount distribution information for the microscopic regions corresponding to relative positions of the microscopic regions

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within the at least one pattern, and comparing the respective microscopic regions of the at least one pattern to the stored information.

Fig. 3 of the application drawings illustrates the use of such information. First, the influence of irradiation of directly adjacent regions on each other is considered in terms of a 3 x 3 matrix of microscopic regions. It is assumed that 70% of ion irradiation occurs at the region at which the center of the ion beam is directed, 5% occurs at regions above, below and to the left and right of the central region, and 2.5% occurs at regions neighboring at an angle. Thus, isolated regions are irradiated at a 70% relative irradiation rate, line end regions are irradiated at a 75% relative irradiation rate, regions within a line are irradiated at an 80% relative irradiation rate, corner regions are irradiated at an 82.5% relative irradiation rate, side regions are irradiated at a 90% relative irradiation rate, central regions are irradiated at a 100% relative irradiation rate, and the like. By comparing microscopic regions within a given pattern to such stored information and controlling the scanning of the charged particle beam in accordance with the comparison results, uniform processing can be achieved.

No corresponding method is disclosed or suggested by the prior art of record.

Veneklasen was cited as disclosing the dividing of a pattern into pixels corresponding to beam diameter, and maintaining a charged particle beam at each pixel location for the same amount of time. Accordingly, Veneklasen fails to disclose or suggest a method of dividing a pattern into a plurality of microscopic regions each having a size <u>slightly smaller than</u> a diameter of the beam, and varying a frequency of the scanning so that each of the respective microscopic regions has an equal dose of irradiation applied thereto by the charged particle beam, as required by claim 7. Nor does Veneklasen disclose or suggest the novel subject matter recited by newly added independent claims 12 and 22.

In accordance with Veneklasen, a periodic analog wide field magnetic charged particle beam scan is augmented by a high speed electrostatic retrograde scan to keep the beam essentially stationary during exposure of rectangular flash fields and/or Gaussian beams such that a staircase deflection trajectory is created for the beam. The position and dose data for each flash is derived from a rasterized data format using a decoder device. Superposition of a sawtooth signal having the appropriate amplitude and frequency on the main raster scan creates a staircase deflection trajectory. For a Gaussian beam, each "stair step" of a deflection trajectory has a width essentially equal to the pixel spacing, with each

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pixel having the size of the beam diameter. By employing this method, the Gaussian beam is essentially held steady relative to the substrate during each exposure (e.g., each pixel). In this manner, asymmetry in critical dimension values caused by differences in the slope of the edges of energy profiles in the resist is reduced or eliminated.

Accordingly, while Veneklasen discloses a method for maintaining symmetry in beam scanning, it fails to disclose or suggest the novel charged particle beam processing method which varies the frequency of a beam scan to compensate for variations in exposure of microscopic regions slightly smaller than the beam diameter so that each of the microscopic regions has an equal dose of irradiation applied thereto by the charged particle beam as required by independent claim 7.

Nor does Veneklasen disclose or suggest the steps of claim 12, including obtaining irradiation amount distribution information for each of the microscopic regions (or pixels) necessary to obtain the same irradiation amount for each of the microscopic regions, and scanning of the charged particle beam across the pattern based on the irradiation amount distribution information. Similarly, Veneklasen does not disclose the steps recited by newly added independent claim 22 involving the storing of information including a charged particle beam irradiation amount and a specific number of directly adjacent microscopic regions within a pattern.

Accordingly, applicants respectfully submit that claims 7-26 patentably distinguish over the prior art of record and that the prior art rejections should be withdrawn.

In view of the foregoing amendments and discussion, the application is now believed to be in condition for allowance. Accordingly, favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

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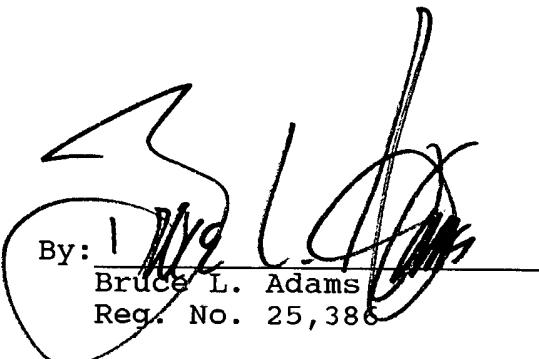
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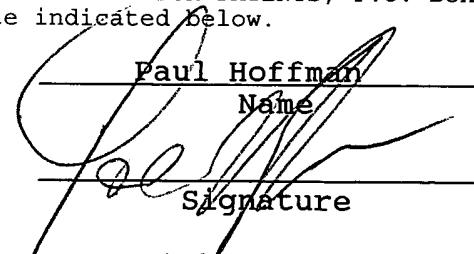
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October 17, 2003

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